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Applicant : Jay A. Stein et al. Art Unit:
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For : DEVICE AND METHOD FOR INSPECTION OF BAGGAGE AND OTHER OBJECTS

Commissioner of Patents and Trademarks
Washington, DC 20231

INFORMATION DISCLOSURE STATEMENT

Applicant hereby makes of record the patents and other references described below and listed on the attached form. A copy of each of these references is enclosed.

Peil, U.S. Patent No. 3,678,278, discloses an inspection apparatus for use with an airline ticket and check-in counter which includes an X-ray and fluoroscopic examination unit and a frequency modulation monitor, all positioned on a frame adjacent a baggage weighing platform. A sliding X-ray impervious shield is supported on the frame and is positioned over the weighing platform and baggage thereon during the X-ray inspection.

Bartko, U.S. Patent No. 3,832,545, discloses an invention pertaining to a nuclear technique for monitoring objects such as luggage and parcels to determine the presence of specified nitrogen containing materials such as explosives as a function of the nitrogen content and concentration profile. Objects to be analyzed to determine the presence of nitrogen are

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subjected to a thermal neutron environment and the gamma ray radiation produced by the object in response to nitrogen reactions is monitored by gamma ray detectors. The gamma ray detectors produce indications of the nitrogen content of the object and the concentration profile of the nitrogen in the object. The information provided by the gamma ray detectors is processed to determine if the measured nitrogen content and concentration corresponds to a class of nitrogen containing material of interest, i.e. explosives.

Macovski, U.S. Patent No. 3,840,747, discloses viewing any section of a radioactive source by placing a multi-aperatured plate between the radioactive source and a gamma ray camera.

Macovski, U.S. Patent No. 3,848,130, discloses a special purpose diagnostic X-ray system which determines the thickness of various different tissues within a body by taking a series of images using X-rays of different energies and then solving the series simultaneous equations relating the thickness of a tissue, its absorption coefficient and the intensity of the radiation penetrating that tissue.

Stein et al., U.S. Re 28,544, discloses an X-ray scanning device for baggage inspection which produces a scanning pencil beam by intersecting a fan beam with a rotating slotted wheel.

Peugeot, U.S. Patent No. 3,919,467, discloses an X-ray baggage inspection system in which an X-ray generator directs a beam through an object of baggage and the resulting image,

appearing on a fluorescent screen, is scanned by a low light level T.V. camera and the image stored, the generator being turned on for a selected number of T.V. scans or frames. The number of frames and thus the intensity of image accumulated and stored in a video scan converter, is controlled by the operator to enable only the radiation exposure necessary to obtain a legible T.V. image, the image being displayed on a T.V. monitor.

Nomura et al., U.S. Patent No. 3,924,064, discloses an X-ray inspection apparatus for baggage whereby regeneration of an X-ray image of an object is disclosed. X-rays are radiated to the object in the form of pulses, and the image is converted to a video-signal for one field and recorded. The recorded video-signal is repeatedly regenerated at field cycle until a next video-signal is produced. In such a system, inspection may be made while the object is being rapidly transferred at an extremely low X-ray radiation level.

Dissing, U.S. Patent No. 3,944,830, describes a medical diagnosis technique for bone density determination employing radiation of two different γ- or X-ray photon energies simultaneously applied to tissue under examination (col. 1, lines 51 - 56, col. 2, lines 67 - 68). To eliminate the influence of soft body tissue on the density measurement, a calibration is performed using a sample similar to the soft tissue (col. 5, line 67, col. 6, line 20). After calibration, the radiation source and detector are scanned in a straight line along the human body part to be examined (col. 6, lines 21 - 24) and an output signal proportional to bone density is produced. A proportionality

factor for converting the output signal to a bone density measurement is determined using a "dummy [i.e. reference sample] made from the two substances [i.e. soft tissue and bone] having a known content of b-substances [i.e. bone]" (col. 4, lines 54 - 58).

Fletcher et al., U.S. Patent No. 3,996,471, describes the method of using photons of two energies to perform bone densitometry for medical diagnosis.

Dennis, U.S. Patent No. 4,020,346, discloses a security inspection apparatus designed for the safe, efficient and rapid inspection of products to detect the presence of objectionable X-ray detectable items. The apparatus comprises a source of continuous X-rays of sufficiently low intensity that conventional photographic film is insensitive thereto, a fluoroscopic screen, a television camera adapted to transmit electrical impulses which provide a visual picture of the images on the fluoroscopic screen to a television monitor and means for intensifying the electrical impulses transmitted by the camera so that the image on the monitor is clearly visible. The apparatus also comprises means for continuously moving products such as baggage between the X-ray source and the screen at a uniform speed within a shielded compartment so that a continuously changing visual picture of the contents of the baggage is displayed on the monitor, providing a three-dimensional picture of each detectable item in the baggage and an indication of its relative location therein.

Alvarez et al., U.S. Patent No. 4,029,963, discloses a diagnostic tomographic X-ray system which uses an energy selective detector to separate an incident polychromatic incident beam into high and low energy components. A computer separates the signal from the detector into an atomic-number dependent and a density dependent component, which can then be used to reconstruct an image which shows atomic-number dependent or density dependent areas.

Dennhoven et al., U.S. Patent No. 4,047,035, discloses a baggage inspection apparatus utilizing an X-ray generator for fluoroscopic examination of luggage and the like in which an X-ray detector is disposed in the beam path of the X-ray generator, operative to control switch means for switching off the high voltage of te X-ray beam generator in the event the intensity and/or duration of the X-ray radiation exceeds a predetermined value.

Dennhoven et al., U.S. Patent No. 4,139,771, discloses a luggage inspection apparatus utilizing fluoroscopic examination in conjunction with an X-ray generator, with the fluoroscopic picture being received by a TV camera, the video signals of which are supplied to an intermediate store for ultimate supply to a TV monitor, the camera containing an AC line-coupled pulse generator for synchronizing the camera and the X-ray flash generator, which pulse generator is electrically interconnected with a synchronizing unit which, upon the initiating of a starting pulse, thus likewise synchronously

triggers the X-ray flash generator with respect to the AC supply line.

Dennhoven et al., U.S. Patent No. 4,210,811, discloses an apparatus for inspecting or screening articles, such as closed luggage and parcels, having a moveable shield to enclose selectively a monitoring duct area in which the articles are placed for screening by X-ray or similar radiation. The shield moves in a fixed housing (which may in turn be mobile) on wheels. A linear drive motor has a shield fixed in the bottom of the housing. The shield carries a rail electromagnetically reactible directly with the strator. Proximity switches in the housing activated by a magnet on the shield control the travel of the shield. A switch located between the end of travel switches may be employed to vary the speed of the linear motor to provide quick, safe cycling of the apparatus.

Kunze et al., U.S. Patent No. 4,216,499, discloses a baggage inspection system utilizing fluoroscopy of baggage pieces and the like, employing an X-ray flash unit, a television pick-up unit for scanning the X-ray image, storage of the television image and subsequent image reproduction by a television monitor, in which, in accordance with the invention, the memory is a digital solid state memory for the digital storage of a half frame, of an interlaced video frame of the television pick-up unit, with a capacity of 6 to 8 bits per image-point of the image signal to be stored.

Kotowski, U.S. Patent No. 4,366,382, discloses a baggage system which employs a fan-shaped X-ray beam which scans

baggage on a conveyor belt and produces images of the contents of the baggage on a video monitor. The output of an X-ray source is collimated into a narrow linear beam. Objects to be scanned are exposed to this beam with successive slices of the object being so exposed as the conveyor moves the object past the beam. A light emitting screen receives the beam after it has passed through the object and emits a light pattern in accordance with the characteristics of the object being scanned. The light output of the screen is received by an array of photodetectors which generate electrical signals in accordance with the intensity of the light received thereby. The outputs of the photo-detectors are sequentially sampled to provide a series of signals in accordance with the photo-detector outputs. These signals are converted to digital form and stored in a memory. The output of the memory is fed through appropriate video output circuits to a video monitor where an image of the object being scanned is displayed.

DeLucia, U.S. Patent No. 4,454,605, discloses an X-ray apparatus for the inspection of mail, parcels, baggage, and the like, for contraband materials by direct view fluoroscopy. The apparatus is of modular design, in that, it includes a first lead-shielded unit which contains an X-ray fluorescent viewing screen, a mirror, a viewing port for the screen, an inspection compartment, and a door to the inspection compartment; and it also includes a second lead-shielded unit which contains the X-ray generator. The units are mounted in a metal cabinet formed of steel, or other material which need not be lined with heavy

lead sheets, or other X-ray impervious material. The first unit is mounted in the upper portion of the cabinet, and the second unit is mounted in the lower portion of the cabinet. X-rays from the second unit are directed through the bottom of the first unit by means of a truncated triangular-shaped guide member formed of X-ray impervious material, such as lead.

Macovski, U.S. Patent No. 4,463,375, discloses in a multiple-measurement system, using weighted sums of the measurements to provide a selective image and an increased signal-to-noise ratio of some desired parameter of the image.

Blaustein et al., U.S. Patent No. 4,530,006, discloses a digital system including circuitry for imaging items passing on a conveyor belt through an X-ray fan beam. The circuitry of the present invention enables detection of the items as soon as the X-ray beam is pierced and an image of the items is maintained on a monitor following removal of the items from the X-ray beam. This enables detection of all items entering the X-ray beam, and subsequent inspection of the items.

Schatzki, U.S. Patent No. 4,539,648, discloses a radiant energy imaging system for selectively enhancing the image of objects having circular cross section to distinguish them from the image of objects having rectangular cross section, such objects being contained in a material having a different density-absorption coefficient product than the objects. In the invention, the gradient image of the spatially resolved transmitted intensity of the radiation is calculated and eroded to preferentially remove the edges of images of objects having

rectangular cross section. The invention finds particular use in detecting agricultural contraband contained in baggage or parcels.

Macovski, U.S. Patent No. 4,549,307, discloses improving the image signal in a fluoroscopic radiation imaging system by measuring the scatter radiation signal and subtracting it from the detected radiation signal.

Dönges et al., U.S. Patent No. 4,566,113, discloses a method for examining the content of containers, which includes weighing the container, comparing the weight of the container with a total weight derived from the net weight of a given load and the product of the volume and the packing weight of the given load, transilluminating the container with a spatially limited high energy X-ray beam, moving the container relative to the X-ray, and determining and evaluating the distribution of the mass attenuation coefficient over at least one surface of the container, and an apparatus for carrying out the method.

Macovski, U.S. Patent No. 4,578,803, discloses energy-selective X-ray images produced using two scintillating screens separated by an X-ray hardening filter. Photosensitive surfaces individually receive the light images from each screen.

Heinze et al., U.S. Patent No. 4,639,943, describes a medical X-ray diagnostic system comprising a closed control loop for the regulating the dosage of radiation from an X-ray source. The system further comprises two detectors for control of the radiation dose from an X-ray source; one detector located between the X-ray source and a patient and one located after an X-ray

image intensifier, and a means for switching dosage control between the two detectors depending upon the detected dose rate.

Makino et al., U.S. Patent No. 4,641,331, describes a medical X-ray diagnostic system comprising a device for measuring the amount of X-rays penetrating a patient and then maintaining the voltage to current ratio for the X-ray source at a constant value, thereby optimizing contrast in the image.

Paolini, U.S. Patent No. 4,644,578, discloses an improvement to a digital system for reading out image information of items passing on a conveyor belt through an X-ray fan-beam. The improvement involves an oscillating screen or mask moving between the items and detector elements with the mask having openings in registration with at most one half of each of several detector elements. The mask oscillates over the detector elements to expose alternate portions of the radiation detecting surface of each of the detector elements to the incident X-rays.

Macovski, U.S. Patent No. 4,686,695, discloses scanning an X-ray beam through a sequence of subsections of a volume, measuring the X-ray transmission at each position at two energies, and processing the resultant transmission signals to produce a signal representing the projected amount of a specific material in the volume. The two energies are chosen so that the mass attenuation coefficients of bone and soft tissue are comparable to each other. The X-ray transmission is collimated after passing through the volume.

Donges et al., U.S. Patent No. 4,736,401, discloses an X-ray scanner for examining objects moved through an X-ray

beam on a conveyor having a detector array disposed at the opposite side of the conveyor from the X-ray source and a pulse generator connected to the motor which drives the conveyor for generating a pulse trail dependent on the speed of the motor, and hence on the speed of the conveyor. The pulse generator is connected to a scanner for the detector array and controls the scan rate dependent upon the conveyor speed. The conveyor speed is controlled such that the quotient of the scan rate and the conveying speed is maintained constant in order to hold the imaging scale constant.

Doenges et al., U.S. Patent No. 4,756,015, discloses an X-ray scanner which generates a fan-shaped X-ray beam through which an object to be inspected is moved and a detector line which generates signals corresponding to the radiation attenuated by the object. The processing electronics includes a comparator for recognizing faulty detector signals by means of which the roll-in of data into the image memory is controllable such that, given a faulty detector signal, the transfer of the information into a memory line allocated to the detector is inhibited. The X-ray scanner also includes an allocator unit which omits predetermined detector channels for the purpose of geometric balancing. Given outage of a detector, its detector channel is omitted by the allocator unit, based on a signal from the comparator, instead of a prescribed detector channel.

Donges et al., U.S. Patent No. 4,759,047, discloses a baggage inspection system having a conveying path for moving articles to be inspected through an X-ray beam. The conveyor

path is disposed between an X-ray source for generating the beam and a radiation detector. The radiation detector consists of a number of individual detectors, with the number of individual detectors per unit length being greater in a first region of the detector than in a second region thereof. The first region is disposed at the level of the conveying path for optimally displaying smaller articles transported by the conveyor path, while the second region is suited for display of larger articles.

Dietrich, U.S. Patent No. 4,783,794, discloses a baggage inspection system having a conveyor path disposed between an X-ray source, which generates an X-ray beam, and a radiation detector for detecting radiation passing through articles on the conveyor path. The conveyor path is formed by two surfaces disposed at a right angle relative to each other, with the right angle being inclined relative to the horizontal so that articles on the conveyor path are forced by gravity to lie against one of the surfaces. At least one of the surfaces is a moveable surface, and the other surface may also be a moveable surface, or a roller surface or a plate against which the articles slide. The radiation detector may be an angled detector row so as to encompass substantially all of the radiation beam within its field of view.

Donges et al., U.S. Patent No. 4,788,704, discloses an X-ray device for scanning objects moving on a conveyor path and for processing the detector signals acquired by the scan having a comparator for identifying faulty signals, the comparator being in a control chain for an image storage memory

such that, in the event of a faulty detector signal, the contents of a memory row preceding the faulty detector signal are transferred into the memory row into which the faulty detector signal, if a correct signal, would have been stored. The system also includes a correction element for generating a reference signal at 100% radiation intensity in which the mean value of a number of measured signals is formed. The system also includes an element for reducing the amplitude of the useful signal during measurement in comparison to the amplitude allocated to a radiation intensity of 100%.

Shimizu et al., U.S. Patent No. 4,817,121, discloses an apparatus for checking baggage with X-rays utilizing an X-ray source for irradiating X-rays toward an object to be checked on a conveyor with a fan-shaped beam, an X-ray detector including a plurality of detecting elements aligned along each of two arms of an L-shape arranged so that one arm extends substantially parallel and another arm extends substantially perpendicularly to a conveying surface of the conveyor means with the detecting elements providing electrical signals in proportion to intensity of the detected X-rays passed by the through the object as measured data, and a picture processor for converting the measured data into a picture signal for display on a display device. The picture processor includes a distortion correcting circuit for processing the measured data from the L-shaped X-ray detector so that the measured data corresponds to data obtained by detecting elements arranged along one straight line.

Macovski, U.S. Patent No. 4,827,528, discloses in a multiple-measurement system, using weighted sums of the measurements to provide a selective image and an increased signal-to-noise ratio of some desired parameter of the image. An improved selective image is formed and the error between the selective image and the improved selective image is minimized.

Doenges et al., U.S. Patent No. 4,841,554, discloses an X-ray scanner for inspecting articles moving therethrough, such as on a conveyor, having a frame on which an X-ray source, a collimator for the X-ray beam, and a radiation detector are mounted. The frame resists flexural and torsional stresses so as to maintain the relative positions of the X-ray source, the collimator, and the radiation receiver in the presence of such stresses. The scanner is mounted in a rack in which the frame is seated by a resilient support. The conveyor which is used to move articles through the X-ray beam between the X-ray source and the radiation receiver is supported by the rack, so that mechanical stresses to the conveyor, such as the placement of heavy articles thereon, are not conveyed to the frame, and therefore do not disturb the alignment of the components mounted on the frame, due to the invention of the resilient support.

Geus, U.S. Patent No. 4,870,670, discloses an article inspection system having separate detectors for primary radiation and scattered radiation which are generated by an article upon being irradiated with X-radiation. The scattered radiation detector is disposed so that no primary radiation is incident thereon. The primary radiation detector is scanned at a

frequency to produce a primary radiation image. The scattered radiation incoming to the scattered radiation detector is modulated at a frequency synchronized with the scanning frequency for the primary radiation detector, so that only scattered radiation is incident on the scattered radiation detector which emanates from the region of the article which is currently being scanned for primary radiation.

Owens, U.S. Patent No. 4,879,735, discloses an improved X-ray baggage inspection device having an input port with a baffle pivotally suspended from an upper edge to substantially occlude an upper selected region of the input port, leaving an open space adjacent to a baggage conveyor having a configuration suited for the passage of briefcase type baggage horizontally disposed upon the conveyor, but which will pivot inward in response to all types of baggage having a height exceeding a preselected distance between the conveyor and the lower edge of the baffle.

Glockmann et al., U.S. Patent No. 4,884,289, discloses an X-ray scanner for detecting plastic articles having an X-ray source which generates a fan-shaped X-ray beam through which an article to be examined is moved. A primary radiation detector array is disposed at a side of the article opposite to the X-ray source and functions to provide a normal X-ray image identifying metal articles. Additional detectors, which detect scatter radiation are disposed around the examination space at a distance from the primary radiation detector. The scatter radiation detectors detect scattered radiation characteristic of

that produced by plastic articles. Signals from the scatter radiation detectors are processed, by which the presence of a plastic article can be identified.

Lehmann et al., "Generalized Image Combinations in Dual KVE Digital Radiography," in Medical Physics, Vol. 8, No. 5, pp. 659-667, Sept/Oct 1981, in the context of a medical diagnostic system, discusses the use of dual energy techniques to remove a specific material from the image.

Sartoris et al., "Bone Mineral Density in the Femoral Neck," in American Journal of Roentgenology, Vol. 144, pp. 605-611, (March 1985), describes a dual-energy projection medical radiographic technique involving moving the body part under examination through a stationary fan beam of X-ray pulses of two different energies, alternating at 60 Hz. The beam detector is an array of 512 0.7 mm cesium iodide detectors (p. 606, col. 1, para. 5). Soft tissue cancellation is accomplished by scanning a contoured Lucite block containing chambers filled with solution having different known density, then scanning the body part with the "Lucite phantom in the radiation field" (p. 606. col. 1, para. 6).

Gustafsson et al., "X-ray Spectrophotometry for Bone-Mineral Determinations," in Medical and Biomedical Engineering, p. 113-118, (January 1974), describes an X-ray tube with alternating high and low voltage levels used for medical diagnosis. The source and detector are in fixed relationship, and scanning is performed in one line while a set of servo-driven step wedges are used to measure the bone thickness and

tissue thickness equivalents. Gustafsson employs one reference detector, a spinning wheel containing X-ray filters, and a scintillation detector in a pulse-counting mode.

Cann, "A Clinicians Guide to the Use of Bone Mass Measurements," is a preprint, not known to be published or presented publicly, received by the inventor from the author. The paper discusses dual photon absorbtiometry for medical purposes (beginning on page 12) and states that either radioisotopes of "filtered X-ray sources" may be used. Cann also makes reference to two scanning techniques, the second of which is "a rectilinear raster scan".

Wahner et al., "Non-invasive Bone Mineral Measurements," in Seminars in Nuclear Medicine, Vol. XIII, No. 3, pp. 282-289, July 1983, describes bone densitometry with photons of two energies, using a two-dimensional raster scan with source and detector in fixed relationship and generation of image from the data.

Dunn et al., "Measurement of Bone Mineral Content in Human Vertebrae and Hip by Dual Proton Absorptiometry," in RADIOLOGY, Vol. 136, No. 2, p. 485-487, (August 1980), describes a technique and apparatus for measuring bone mineral content, including a collimated beam (4mm in diameter, p. 486, col. 2, para. 2) from a ^{153} Gd source (a radioactive isotope). The energy spectrum of the source "has predominant photoelectric peaks in NaI(T1) [the detector material] at approximately 44 and 100 keV" (p. 485, col. 2, para. 2). the source and the detector

are scanned in both the x and y directions across the object to be examined (see Fig. 1 and p. 486, col. 2, para. 2).

The "Norland Dichromatic Bone Densitometer" pamphlet describes conventional radioisotope DPA. A medical diagnostic scanning unit is described which "can move in any direction (X, Y, or at any angle)."

The article "U.S. says American Airlines has poor security record" from The Boston Globe of February 18, 1989 recites the use of scattered and absorbed X-rays to detect explosives.

Alvarez et al., "Characterization of the X-ray Attenuation Properties of Explosives and Their Implications in Baggage Screening", Report No. FAA-RD-79-50, March 1979, discloses dual energy computed tomographic systems as preferable to dual energy projection X-ray systems.

EG&G Astrophysics brochures disclose single energy scanning X-ray projection systems for baggage screening using photo diodes and multi-image electronics able to discriminate inorganic materials from organic materials.

Scan-tech Security brochure discloses single energy X-ray projection system for screening baggage providing operator-accessed image processing such as edge enhancement and dense item alert.

Heimann Systems Co. brochures, 1989, disclose single and multiple energy X-ray projection systems for screening baggage providing image contrast and edge enhancement and

material classification by three contrasting colors, discriminating organic materials from inorganic materials.

Respectfully submitted,

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